1st Workshop on Exploring the Fitness and Evolvability of Personal Learning Environments (EFEPLE'11)

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Workshop #5

WHITE PAPER

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1. Introduction

1.1 Motivation

In the recent decade a plethora of interactive software tools, be they open source or proprietary, have emerged and perished in the realm of technology-enhanced learning (TEL). Concomitantly, there have also been surge and demise of contents, social networks, and activities associated with the use of these TEL tools. It is intriguing to understand what factors contribute to their rises and falls, and how. While controversies on the viability of making an analogy between the evolution of natural and artificial objects prevail, it is deemed worthwhile to explore its potential for analysing the changes in TEL and charting the future.

In accordance with evolutionary theory, the fitness of an environment or tool can be defined with respect to its purpose and depends on the 'genes' from former generations. In context of TEL, these genes can be understood as features of existing tools and functionality being reused from software libraries or developed over multiple lifecycles thus leading to new generations of software artefacts. Personal learning environments (PLEs) aggregate these functionalities to enable learners to connect to peers and shared artefacts along their learning activities. Consequently, the success of a PLE can be measured by its uptake and usage within different communities of practice, its perceived effectiveness and efficiency in supporting the attainment of learning goals, its application beyond pre-defined purposes, its distribution and outreach beyond single communities, and its evolution to new PLE generations through active developers. Moreover, data mining of so-called *variables of evolvability* (e.g., perceived pragmatic/learning and hedonic/fun value) will enable the derivation of specific guidelines for designing and developing PLEs. Such empirically grounded guidelines, supplementary to those for generic IT applications, are currently lacking and much desired.

Overall, the main aim of the workshop is to explore the fitness and evolvability of PLEs in order to identify and understand characteristics and mechanisms for successfully evolving PLEs.

1.2 Related Work

In principle, for a software system to be sustainable, it needs to be able to adapt to the changing requirements [1] in terms of use contexts, user goals, organizational cultures and technological opportunities. Specifically, in the field of TEL, there has been a shift from the pioneer work on designing and implementing full-featured, organisation-driven learning management systems (LMSs) to the emerging trend of developing specialised tools, which then can be assembled by users to extend/create personal learning environments (PLEs, Attwell, 2007) [2]. Not least due to the Internet, users have access to a seemingly innumerable amount of content and software tools, which are useful and partially even necessary to achieve the learning goals driven by the demands of job tasks, higher, and further education, or even private activities.

In the context of PLEs, the selection of tools is at the discretion of individual users, their organisations and the communities of practice (CoP) where users engage in a variety of collaborative activities. It is observed that some software tools, after being used for a few typical tasks by a few people only, unexpectedly spread out within a CoP widely as well as wildly through good practice sharing, convincing peers of the benefits of these tools for particular lifelong learning activities. In a very short period of time such tools can become as must-have infrastructure for collaborative work (e.g. various Google services). These tools and the environments built on them are not only intensively used but are also modified and sustained by active developer communities. On the other hand, some tools are endangered to be rejected by end-users and to die out after a few successful cases of application, even though they have undergone several iterations of redesign. Apparently, these observations manifest the notions of *descent with modification*, *heritable variation and selection, sensitivity to changing environmental or contextual requirements, and "control of and types of variability"* (Nehaniv, 2003 [3]; Wernick et al. 2004 [4]) that characterize Darwinian evolution. In the context of PLEs, it is relevant to understand the processes leading to successful tool uses, create respective models and learn how to control respective processes to increase the efficiency and effectiveness of modern individual learning environments.

The assumption that changes in PLEs can be modelled by Darwinism underpins this proposed workshop, which aims to explore several pertinent issues:

- Nahaniv et al [5] (2006) define the notion of *evolvability* as "*the capacity to vary robustly and adaptively over time or generations in digital and natural systems".* This definition leads to a basic question: **What is evolvable**? Is it a matter of the complexity of a system that is quantifiable such as lines of codes, number of modules? Or is it more a matter of quality-in-use manifests in terms of user experience [6] (i.e. a non-functional requirement)? Another key question: **Why does a system evolve?** It can be instigated by changes in a system's environment, user requirements, usage, implementation methodologies and technologies. Answers to these *what* and *why* questions can shed some light onto the question **How to effectively and reliably evolve a system** (Ciraci & van den Broek, 2006; footnote 3)? Addressing these questions in the context of PLEs will instigate stimulating discussions.

- Fitness for survival is a widely known but poorly understood concept of Darwinian evolution. Paradoxically, the idea of heritable variation and selection is necessary but not sufficient to explain inherent phenotypic expression of fitness (Nehaniv et al. 2006; footnote 5). It hinges on the rigidity (or flexibility) of the genotype-phenotype mappings. The main difficulties lie in drawing analogies between biological concepts and artificial artifacts (e.g. What constitutes an “individual”, a “species”, or “interbreeding”). Insights can be gained from the notion of *fit-for-purpose* in the field of HCI (e.g. Wong et al., 2005) [7] and the fitness model of nodes in the science of (social) networks (Barabasi, 2002) [8]. Nonetheless, it remains an open question on how to define and measure the fitness of PLE tools.

2. Workshop Description

There were 10 presentations, including a keynote speech. In addition, plenary discussions on specific topics were held. Section 2.1 reports the main ideas addressed by individual presentations. Section 2.2 highlights the ideas explored by the workshop participants.

2.1 Report on Presentations

2.1.1 Keynote speech by Prof. Chrystopher Nehaniv, University of Hertfordshire, UK

- Core concepts addressed: individual, reproduction, population, robustness, variability, phenotypic plasticity, autopoiesis, self-replication and repair, and evolvability
- The notion ‘replicating individual’ is difficult to define in the realm of software evolution – Is it a behaviour, an artifact or software release?
- Self-replication is a key notion in evolution (cf. computer viruses, cancer cells, self-reproducing automata); replicators entail external support;
- Constraints of evolution: finite resources, heredity, variability, differing reproductive success, turn-over of generations;
- Increasing complexity through successive inheritable mutation; a measure of complexity in biological sciences can be number of cell types and in software can be level of embeddedness, lines of code, number of loops, etc.
- Adaptive changes in population over generations (genotype-phenotype map)
- Artificial selection vs. natural selection;
- Variability: neutral mutation (no harm, no benefit) is important: similar fitness in the same environment; mutation that is neutral in such an environment is beneficial as a resource;
- Neutral mutation such as user interfaces – a variety of choice for selection;
- Fitness landscape: inheritable fitness to flourish
- Open-ended evolution is unbounded increase of complexity over time;
- External fitness function imposed on agriculture (can we learn from this domain?); number of offspring and living long enough to reproduce (fitness measures);
- Symbiogenesis: dynamic user-synthesis of PLE from components; combinations from the lower level units;
- Evolvability for artefacts: capacity for producers to rise to adaptive variants for flexibly meeting changing requirements; lineage, different fitness between offspring and parents
- Properties of evolvable systems: robustness to genetic variability, phenotypic robustness, redundancy, conservation of core mechanisms/features; robustness to environment change (resilience), self-monitoring, compartmentalization (modularity), symbiogenesis
- Software evolution: re-use, modularity, information hiding, encapsulation, OO inheritance, coupling and cohesion;
- PLE: system as fielded (instance: individual)
- Persist over time, descent with modification
- Lines of code, modules can be considered as genes (re-usable)
- Variation: customization of generic software product via parameterization, copying and sharing
- Iteratively adapted by users to context and changing requirements;
- Immediate fitness is very different from capacity to support possible evolvability;
- Variational capacity (vary/be varied robustly and adaptively) is crucial to evolvability

2.1.2 Discussion on the keynote speech

- Notion of energy/resources in the context of software;
- Areas of tension:
  - immediate fitness vs. variability
  - simplicity: usability vs. complexity
  - genotype (design: functionality) vs. phenotype (affordances: practices)
- Complexity: base is interaction, energy comes from interaction, non predictable
- Consciousness/Intentionality (or awareness): comes from interaction, collaboration
- Is evolvability kind of higher level creativity
- Success: performance improvement of learners; "form follows failures"
- Complexity: maximise contact with environment subject to being able to understand and manipulate: complexity needs to be close to contact
- Educational technology so far has failed: because there are no solutions of scale (past: LMS have been successful, but not 'real' learning support tools)
- Capacity for variability: Learning is development of potential for action: competence, but we can only assess performance
- Capacity relates to complexity through adaptation through exchange of modules and over time!
- Freedom of adaptation vs. ethical concerns experimenting with bad combinations of software
- Sharing of successful practices/arrangements/etc. is hereditary replicability
- Problem: It's not the PLEs surviving and being fit, it's the widgets
- Problem: PLE: Livespan of generations is not controlled
- But: Behaviour vs. artefacts: patterns of practices vs. widgets
- Behaviour: duplication and divergence; behaviour patterns can be very far away from genetics; active copying vs. environment driven auto discovery
- Controlling of behaviour: we can (to a part) control the environment to recreate 'situations'
- Translation of behaviour (phenotype) into genotype? No convergence in other areas.
- Would be helpful to very clearly define concepts such as genotype, phenotype in the PLE context
- Groundbreaking works in e.g. evolutionary algorithms: e.g. von Neumann: theory about live; e.g. evolutionary algos: were designed as optimisation techniques (example: designing nozzles, aircraft wings)

2.1.3 Presentation by Benham Taraghi

- Success measurement:
  - Complexity: number of widgets in an environment
  - Change: rate of change: number of replacements, new widgets
  - Number of users
- Selection types: stabilising selection, disruptive selection, directed selection
- Selection strategies: r-strategy (short livespan, unknown environments) vs. K-strategy (long livespan, known environments)
- Mutation: slight variation of existing functionality or UI
- Recombination: combining code of different widgets to build new ones: code sex
- Tracking of use: frequency of activated widgets, frequency of interactions with widgets that can be tracked in the system
- TUG system: 1000 users, 30% active users
- Competition not between widgets, but between PLE system and competing websites
- Code complexity of the PLEs: PLE as a whole (of one user) or widgets? How did it change over time? Lines of code? Level of embeddedness? Modularisation? Interwidget communcation? Service orientation?
- Affordances (= in a certain cultural context)?
- Other factors (besides fitness): usability, usefulness (e.g. indirect via level of the learners)?
- Need to look at overall PLE system, not only at single widget; still: number of contexts, number of functions, number of other widgets it has been used with (degree centrality, betweenness, prestige): indicator of complexity
- Symbiotic relations: themingWidget: cannot exist on its own

- Coevolution of development and users

2.1.4 Presentation by Carlo Giovanella

- Evolution: strong focus on learning analytics: e.g. activity graphs, emotions, social networks, emotion in social networks
- Use **traces of user activity** to observe evolution
- Arrival of facebook changed the use of the system
- New journal: Interaction Design & Architecture

2.1.5 Presentation by Felix Moedritscher

- Environment: socio-technical system: activities, purposes, patterns, interaction, features, functionality, implementation
- Evolvability: versioning, copying/reusing, interoperability
- Fitness: usefulness & usability, user feedback, technological compliance
- Distribution approximation
- Fitness depends on the usage context (e.g. publication impact)
- Impact of papers very strongly relates on experience of the researcher (years of experience in a field). What about production of widgets? Are widgets produced by more experienced users more successful?

2.1.6 Presentation by Martin Memmel

- Sustainability
- Interoperability: using and offering APIs, following standards
- Number of application scenarios: very many application scenarios for PLEs
- Low technical and low conceptual barriers to system use
- Resources are finite: people, time, infrastructure, money
- Repurposing and re-theming/branding of systems
- Solve a specific problem, but do it in a generic way
- Support tools for setup and deployment
- Refactor
- Fitness is plasticity with respect to user requirements

2.1.7 Presentation by Sandy El Helou

- Viability:
    - flexible representation of interaction and contents
    - adopt social media paradigms (encouraging participation)
    - elastic community and CMS services
    - automate/openness: recommender systems: open corpus environments
- Use of Graaasp
- Flexible representation: not necessarily dependant on number of users

2.1.8 Presentation by Jose L. Santos

- CAM dashboard
- Activity – actions executed in widgets
- Capturing communcation data from interwidget communication
- Specialisation to styles?
- Active use of the dashboard to change behaviour?
- Evolution: Awareness > Social Behaviour > …
- How to support awareness between developer and user?
- Representation of context to make use of the activity monitoring
- Fitness: take care of environment
- Visual quality
- Trust relationship between developers and user

2.1.9 Presentation by Fridolin Wild

- Acceptance: expectancies, social influence, facilitating conditions etc.
- Longer term

2.1.10 Presentation by Christian Prause

- "Walking on water and developing software from a specification are easy if both are frozen." (Edward V. Berard)
- high costs of change lead to extinction
- evolvablity: internal quality
- software quality: ISO 9126: functionality, reliability, usability, efficiency, maintainability, portability
- developers learn software: documentation! Code!
- Fitness = external quality + quality in use = Tool in environment in its context
- Case-based tools

2.1.11 Presentation by Maryam Najafian-Razavi

- Barriers to adoption (of gleanr)
  - Lack of simplicity
  - Slow ROI: differed benefit
  - Need for training
  - Usability problems: memorability, error rate, portability
  - Success factors: clear value prop, awareness, ease of integration
  - Interesting: big and fluid sites show up earlier in google
  - Suggestions: anonymity, prepopulation, network effects
- Success factors: could be fitness factors
- Fitness leads to adoption
- Prepopulation: problematic and difficult
- Prepopulating vs. survival?
- Ecosystem: has to be created, needs a context

2.2 Report on Plenary Discussions

2.2.1 Contextual Issues

- Flexibilisation of technology support for any kind of educational process
- Culture of certification: assessment and accreditation;
- Fitness: Integration of environments: mobile, web, all
- Fitness of users: critical design skills, measure experience / styles
- Context: capture context of learners holistically, make this context description available to sound applications;
- Plasticity: Support change in pedagogical approaches

2.2.2 Teachers as Target Groups

- Find a way to prove to the teacher that relying on a specific technology will help them be more effective
- Tackle danger for teachers: environments disappear: but environments change with their needs
- How to sell technology to the teachers?
- Show that with the help of any technology, the learners in the classroom/course became 10% better: works only with criterion-referenced testing (no norm referenced testing): skills assessment: increase by 10%
- Emergence of new widgets coming from the teacher and learner community
- Living community: Increased sharing of best practices: 1 million teachers / million learner using a PLE; There are enough teachers in Europe

- Digital literacy of teachers is a problem
- Technology is seen as an amplifier
- Combine agents and human tutors to provide high quality tutoring to every child

2.2.3 Invisible PLE

- very low entry barrier
- Sharing a curriculum in 15 minutes
- No good idea: it is rather about reconfiguration, not sharing: more about the adoption than that it is fast
- Extremely complex issue
- Widgets: 1000 widgets: which one is better and how do we measure that? Through the community
- Testing: could include teacher has to be able to re-use a PLE in 15 minutes; but: it's not about time, it's about the return on investment
- Identifying the scores that someone gets based on the traces that someone leaves in the system
- Pedagogically sound user interfaces

2.2.4 Predictive Modelling

- Predictive models: Predicting performance based on traces
- Testing of predictive models in competitions: accuracy vs. satisfaction
- Learning analytics: graphical user interfaces that foster quick understanding of performance and aesthetic display, streaming feedback
- Learning analytics, traces, context capturing; Privacy-ensured, anonymised; Streaming analysis
- Open requirements elicitation: Implicit requirement modelling, helpdesk monitoring, Implementation competitions in the bartering platforms for software development

3. Emerging Research Questions

- *Find a way to prove to the teacher that relying on a specific technology will help them be more effective*
  - The million practices & million teacher challenge: ad hoc formation of large scale learning networks: Reach a certain level of scale in variability and build capacity for variablity of practices of technology use in learning and teaching.
  - This includes: sharing of context information such as attention meta data, interoperability, practice capturing and sharing facilities such as scripts or learning designs or activity streams
  - This is not about showing that a certain template is used by a million people, but that 1 million people have differing, adapted to their needs practices in technology support
  - Ad hoc formation of large scale learning networks
- *Fitness of learning environments is **plasticity** with respect to user requirements:*
  - Variation: Adaptation or mutation: construction set widget-based PLE, coding according to changing user requirements, mash-ups
  - Speed of change:
    - Evidence that a trajectory is followed that a system has been adapted: evidence of plasticity
    - Knowledge management for teachers
    - Dissolving of communities of practices: problem solved, community dissolved
- *Invisible PLE*
  - Low entry barriers
  - Flexibility with respect to pedagogical and andragogical approaches
  - fitness of widgets: create an open market for widgets; then we can use the market mechanisms; show that there are widgets from each of the European countries;

differing learning contexts (school, university, lll) and stakeholders (providers, learners, teachers, educational institutions)

4. Grand Challenges

4.1 Grand Challenge 1 (GC1): The million practices & million teachers challenge: ad hoc formation of large scale learning networks

In the educational area, technology is considered an enabler for successful and collaborative activities supporting learners with the increasing complexity and dynamics observable in all knowledge domains and leading to meaningful outcomes. Although being fostered by various European research programmes, a shift in funding strategies can be identified. Instead of pushing technologies for organizational driven teaching and learning more attention is paid to learner-centric approaches fostering competences beyond professional ones, i.e. digital literacy and social competencies, in order to prepare and strengthen individuals for acting in digital ecosystems. Amongst others, EU projects like ARISTOTELE, GRAPPLE, IMREAL, MATURE, METAFORA, ROLE, and TERENCE indicate the importance on transcompetences, personalized learning experiences, collaboration and reflection. Other research, for instance the projects 80DAYS, ALICE, COSPACIAL, GALA, ITEC, or V-CITY, focus on interactivity of content, educational games, or learner characteristics beyond domain-specific knowledge.

By understanding a learner as an actor in a learning ecology, TEL research has started to capture and anaylse the interactions of a learner with her environments which can be characterised as (ad-hoc) networks of actors, artefacts, tools, activities, and communities. In the beginning strongly motivated by being a counterpart to managed learning technology, streams like personal learning environments (PLEs) have emerged over the last few years with the aim to empower learners to design their own environments and to connect to learner networks to collaborate on shared artefacts and goal achievements (Wild et al., 2008; Van Harmelen, 2008). EU projects like ROLE, ITEC, or LTfLL have been investigating into PLE technologies and approaches.

From a more technical perspective, app and widget technology is being developed and applied for learning in many different settings and for different purposes, as reported by projects like ROLE or ITEC. The overall goal here is about reaching a certain level of variability in using technology for learning. On the other hand, interopability has being investigated on different levels and in various EU projects, such as ICOPER or ROLE, as well as in various R&D communities, like CSCW, SCORM, IMS etc. Basically these standardisation movements aim at making learning objects, learning designs, or educational scripts accessible for others in order to foster sharing and reusability of educational resources.

In fact, one grand challenge in the European Educational Area deals with reaching a certain level of scale in variability, e.g. flexibility of learning technologies, and building capacity for sharing and consuming practices of technology use in learning and teaching. Variability and the capacity for variability is a precondition for a flexibly changing learning environments. Therefore and to assist evolution of teaching with technology, the grand challenge aims at providing facilities so that a million different (individual) practices describing differing technology arrangements (e.g. a widget space in a PLE) are shared. It is not an explicit goal to show that a certain practice is used by a million people but that a million people have differing, individual needs and practices in technology support.

Grand challenge 1 includes several necessary achievements:
- *Practice capturing and sharing formalisms* such as scripts, learning designs, or activity streams
- *Facilities to capture context information* such as attention meta-data
- Means for *interoperability*

- Understanding, building, and sustaining *networks of teachers*, including ad-hoc formation and dissolution of such cliques
- Large *tool repositories* such as widget- and app-stores

Building capacity for variability includes:
- Supporting change in pedagogical approaches, shifting the focus from instructional theories and course-based teaching to *environment design capabilities and outcome-oriented learning*
- Finding ways to evidence to the teacher that *relying on a specific technology* will help them be *more effective*
- Since a constantly changing tools portfolio brings along the danger of environments disappearing, teachers have to be supported in meeting this with resilience. This may include *inexpensive benchmarking methods for assessing effectiveness or efficiency gains* that can be achieved with certain practices of technology use.

The degree of variability can be studied and measured. There has to be a significantly large number of differences, which can be assured by investigating provenance (contributions from all EU countries), position in lifelong learning (school, university, continuing professional development or work place learning), stakeholders (teachers, learners, providers, institutions, policy-makers), heterogeneity in practice (activities supported, different flows for the same aim) and tools (arrangements of widgets, combinations of web apps). The 'million people, million practices' benchmark could be seen as a 'hard' target, whereas evidencing a sufficent level of variability could be let up to the applicants in the challenge.

4.2 Grand Challenge 2 (GC2): Fitness of learning environments is plasticity with respect to user requirements

Plasticity of learning environments is their ability to flexibly adapt (or be adapted) to changing requirements. Learning environments are complex ecosystems. Creating plasticity refers to increased mass individualisation of practices and accompaning technology support.

This involves:
- Supporting digital literacy of the teachers.
- Technolology as an amplifier.
- Increasing the speed of change.
- Identifying means to evidence that a trajectory is followed that a system has been adapted: providing means to evidence pasticity.
- Knowledge management for teachers
- Understanding and facilitating the ad hoc formation and dissolution of communities of practices: problem solved, community dissolved.
- Environments of scale.
- Investigating mutation, variability, and fitness of learning environments.
- Building developer – user communities (coding on demand, mash-ups and end-user development, improved human-computer interaction).
- Providing means for quick.
- Flexibility with respect to pedagogical and andragogical approaches
- Low entry barriers.

This could be measured via an open market: when e.g. an open market for widgets and educational practices exists (widgets that are embedded in individual practices that are shared), the market decides which ones are best.

4.3 Grand Challenge 3 (GC3): One tutor per child

Human tutors can be assisted by technology to help learners become more competent and meet the demands of our knowledge-driven society. An individual tutor for every child in Europe (and beyond) is a desideratum that so far cannot be reached. With the help of predictive models and learning analytics, this area could be significantly strengthened. Combining agents and human tutors to provide high quality tutoring to every child can be achieved.

This involves the research of:

- Predictive models: Predicting performance based on traces
- Testing of predictive models in competitions / evaluation forums. Such evaluation competitions are available in other fields: e.g. search engines are evaluated in yearly cycles (with varying focus points) in TREC and CLEF. Evaluations can be done along two lines: accuracy vs. satisfaction.
- Learning analytics: graphical user interfaces that foster quick understanding of performance supported by aesthetic displays; streaming feedback provides real-time support in analysis
- Open requirements elicitation: Implicit requirement modelling, helpdesk monitoring, Implementation competitions in the bartering platforms for software development
- Developing shared methodologies for evaluating effectiveness gains of teachers and learners
- Pedagogically sound user interfaces
- Research of digital identity, privacy, and trust

A set of traces (with objective, human assessed performance scores) can be provided to evaluate the predictive models / learning analytics against. A test set (with non-disclosed human performance scores) can be retained to be used in the a competition.

5. Researchers and Communities

To tackle the three aforementioned Grand Challenges (GC), a broad spectrum of expertise is required. It is crucial to involve researchers from a variety of fields, including biology, mathematics, statistics, computer science, engineering, education, sociology, marketing and management, psychology, and anthropology. The orchestration of contributions from such an interdisciplinary and multidisciplinary team is a mega-challenge per se. Boundary objects [9] such as design artefacts need to be established to facilitate scientific discourses among them. It is deemed indispensable given that individual fields adopt different values, assumptions, and metaphors.

A team with such diverse expertise is typical of the field human-computer interaction (HCI). Members of the HCI community can roughly be classified as academics and practitioners. Another dichotomous categorisation is researchers and designers, although there are numerous sub-categories under these broad terms. Specifically, in addressing the GC1 above, communities of teachers are a must. Concomitantly, learners, policy makers and administrators with which teachers frequently interact will definitely be involved. For GC2, software engineers, interaction designers, and evolutionists/biologists are key players. For GC3, specialists in education technology, statistical modelling, and evaluation methodologies are essential.

Furthermore, it is necessary to construct as well as validate theoretical frameworks with representative target groups, be they teachers, learners, developers, designers and researchers. Mixed method approaches involving different stakeholders, techniques, tools and resources are required to triangulate complex findings. Besides, longer-term studies capturing required data over time are recommended. With the use of Web2.0 applications, multi-source data can be gathered, analysed and reviewed collaboratively to generate richer insights into the issues of interest.

6. Concluding Remarks

Evolutionary or Darwinist theories are inherently controversial; applying them to explain and predict the trajectory of the development of Personal Learning Environments (PLE) is particularly challenging. PLE is still at its infancy stage, and a consensual definition is still lacking. Amongst others, the task of defining fitness models for predicting the rise and demise of specific widgets (which are commonly seen as the building blocks of PLE) and a specific configuration of PLE per se is daunting. The workshop is seen as the first step moving in the direction, though there are still many steps to be taken to achieve this seemingly insurmountable task. The initial step is seen as successful with intriguing ideas being conceived. Future work includes organizing a series of related workshops/seminars that involve participants with diverse backgrounds. Project proposals addressing the emergent topics are seen as a promising way to explore them in depth over a relatively long period of time. In the meantime several meetings amongst the workshop participants have been held to explore these possibilities.

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